NWCA 2011 Mid-Atlantic Tidal Wetland Analysis

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New Jersey Water Monitoring Council

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NWCA 2011 Mid-Atlantic Tidal Wetland Analysis

- Context NWCA 2011 Mid-Atlantic Assessment
- Background: Ordination methods
- Mid-Atlantic Ordination (PCA) Results

Context for analysis of NWCA 2011 Mid-Atlantic Tidal Wetland Data

- NWCA 2011 resulted in a nationwide assessment of estuarine herbaceous wetlands (EH) for the entire USA , not representative for a state or ecological region.

- Nationwide estuarine herbaceous (tidal) wetlands 58% were reported in Good condition. However, New Jersey estuarine wetlands are known to have naturally low floristic diversity but are impacted by numerous stressors.

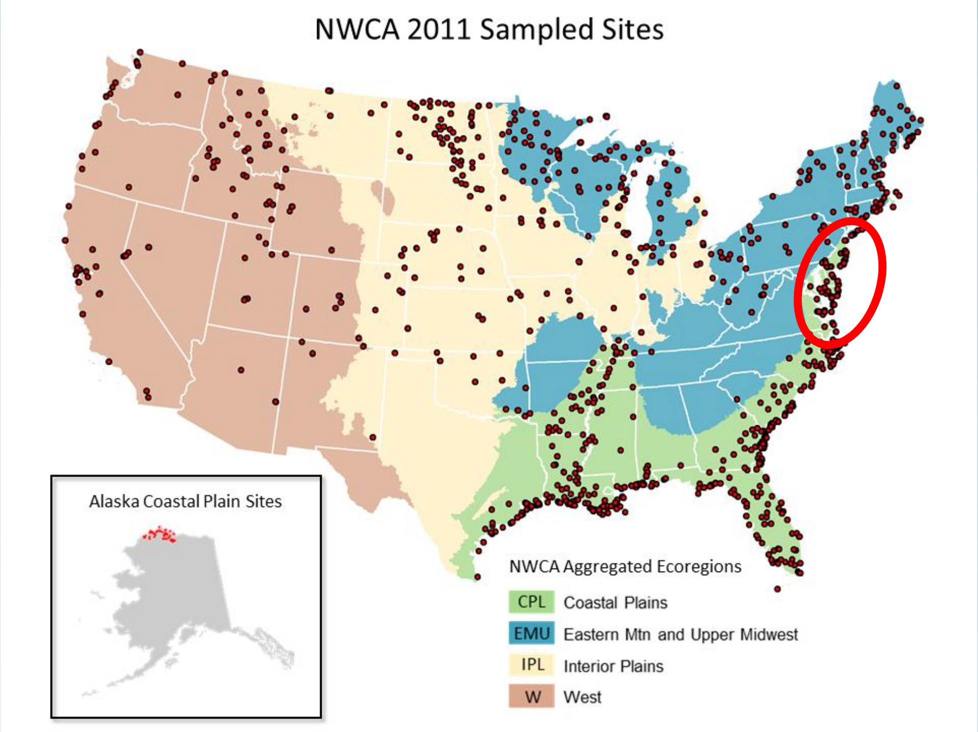
- Algae and Diatom data were not included in the nationwide analysis and final reporting on wetland condition. Data for Mid-Atlantic states were analyzed by Academy of Natural Sciences at Drexel University.

- EPA HQ gave NJDEP permission to analyze a subset of tidal estuarine herbaceous wetland data from the Mid-Atlantic (64 sites) and provided statistical support.

Estuarine Intertidal Wetlands Nationwide

258 Estuarine Herbaceous (EH) Sites representing 4,987,824 acres

*"**Estuarine herbaceous wetlands** have an estimated **58% of wetland area in good condition**, 17% in fair condition, and 26% in poor condition based on the VMMI."*



Mid-Atlantic Estuarine (EH) Sites

	EH	Wetland Condition (VMMI)		
State	# sites	Good	Fair	Poor
NY	6	83% (5)	0% (0)	17% (1)
NJ	**15**	**73% (11)**	**20% (3)**	**7% (1)**
DE	11	36% (4)	9% (1)	55% (6)
MD	22	36% (8)	14% (3)	50% (11)
VA	10	80% (8)	10% (1)	10% (1)
Total	**64**	**56% (36)**	**13% (8)**	**31% (20)**

4 Biological Condition Metrics

1. Vegetation Multi-Metric Index (VMMI)
2. Diatom Shannon-Wiener Diversity Index (SW Diversity)
3. Diatom Dominants (Dominant Diatom)
4. Diatom Centric/Pennate Groups (Centrales/Pennales)

4 Stressor Metrics

5. Nonnative Plant Stressor Indicator (NPSI)
6. Soils Heavy Metal Index (HMI)
7. Hydrology Disturbance Index (HDIS)
8. Buffer Disturbance Index (B1H)

Biological Condition Indices

1. Vegetation Multi-Metric Index (VMMI)
   - Floristic Quality Assessment Index (FQAI)
   - Relative Importance of Native Plant Species
   - Number of Plant Species Tolerant to Disturbance
   - Relative Cover of Native Monocot Species
2. Diatom Shannon-Wiener Diversity Index (SW Diversity)
   - Diatom Taxa Richness
   - Diatom Taxa Evenness

3. Diatom Dominant Taxa (Dominant Diatom)
4. Diatom Centric/Pennate (Centrales / Pennales)

Biological Stressor Indicator

5. Nonnative Plant Stressor Indicator (NPSI)
    - Relative Cover of Nonnative Species
    - Richness of Nonnative Species
    - Relative Frequency of Nonnative Species

Phragmites australis (Common reed)

Environmental Stressor Indices

6. Soil Heavy Metal Index (HMI)

   Sum of heavy metals present at any given site with concentrations above natural background levels based on published values.

   - ✓ Silver (Ag)
   - ✓ Cadmium (Cd)
   - ✓ Cobalt (Co)
   - ✓ Chromium (Cr)
   - ✓ Copper (Cu)
   - ✓ Nickle (Ni)
   - ✓ Lead (Pb)
   - ✓ Antimony (Sb)
   - ✓ Tin (Sn)
   - ✓ Vanadium (V)
   - ✓ Tungsten (W)
   - ✓ Zinc (Zn)

Environmental Stressor Indices (Cont’d)

7. Hydrologic Disturbance in the AA (HDIS)

   ∑ Sum of hydrologic stressors in the AA:

   - Damming features (dikes, berms, dams)
   - Impervious Surfaces
   - Ditching and Culverts
   - Hardening (compaction)
   - Filling/Erosion

8. Buffer Disturbance Index (B1H)

   ∑ Sum of stressors in the Buffer:

   - Agriculture Disturbance
   - Residential and Urban Disturbance
   - Industrial Disturbance
   - Hydrologic Modifications
   - Habitat Modifications

Ockham’s (or Occam's) razor: invaluable philosophical concept because of its strong appeal to common sense

PLURALITAS NON EST PONENDA SINE NECESSITATE
Plurality must not be posited without necessity
Entities should not be multiplied without necessity
It is vain to do with more what can be done with less

An explanation of the facts should be no more complicated than necessary
Among competing hypotheses, favour the simplest one that is consistent with the data

J. Birks

Ordination methods

- **Ordination** – term first presented in ecology by David Goodall in 1954, derived from German ‘ordnung’
- **Ordering** of samples and species in relation to their overall similarity (indirect gradient analysis) or to their environment (direct gradient analysis)
- End result is a **low-dimensional** representation of multivariate data (many objects, many variables). Axes are chosen to fulfil certain mathematical properties
- Great use in **data summarisation**, **data analysis**, and **data interpretation**

Ordination methods: properties of ecological data

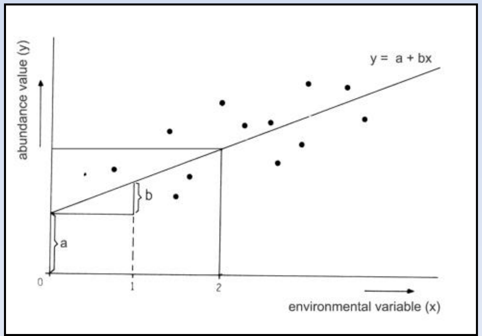
- Many taxa (50-300) and many zero values
- Many samples or objects (50-500)
- Few abundant taxa, many rare taxa (noise)
- Large number of factors influence biota
- Intrinsic dimensionality is low
- Data are not normally distributed in a statistical sense so classical statistical tests are not appropriate
- Much redundant information – similar species distributions

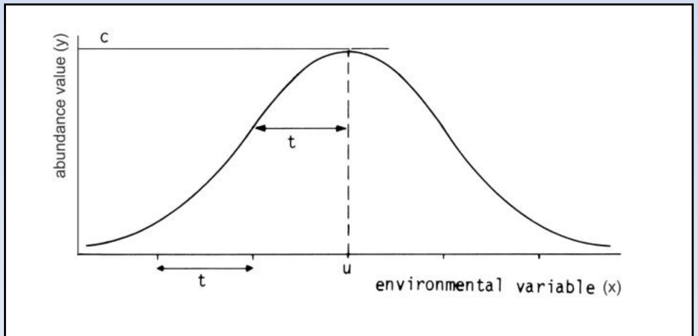
Why do ordinations?

- 1. Impossible to visualize multiple dimensions simultaneously. Data simplification and data reduction - “detecting signal from noise”, avoids misinterpretation.
- 2. Detect features (interpretable environmental gradients) that might otherwise escape attention.
- 3. Statistical power is enhanced when species are considered in aggregate, because of redundancy
- 4. Data exploration as aid to further data collection.
- 5. Communication of results of complex data. Ease of display of complex data.
- 6. We can determine the relative importance of different gradients; this is virtually impossible with univariate techniques.
- 7. Tackle problems not otherwise soluble. Hopefully a better science tool.
- 8. Fun!

Ordination Methods

- Species data **Y** only - ordination, classical ordination, **indirect gradient analysis**, classical or metric scaling, non-metric multidimensional scaling
- Eigenanalysis based:
  - Principal components analysis (linear) PCA
  - Correspondence analysis (unimodal) CA
  - Detrended correspondence analysis (unimodal) DCA
- Also distance-based:
  - Principal coordinates analysis (metric scaling) PCoA
  - Non-metric multidimensional scaling NMDS





Principal Component Analysis (PCA)

- Is there a hidden gradient along our samples which vary with regard to species composition?
- **PCA** is the ordination technique that constructs the theoretical variable that minimises the total residual variance after fitting straight lines or planes to the species data.
- Horse shoe effect if species have unimodal distribution

Ordination interpretation rules

Most important variables have longest arrows

•The longer the arrow, the stronger increase magnitude

Angles between vector arrows approximate their correlations (high + correlation at small angle, negative at > 90 angle
Variables at a 90 degree angle are not correlated)

Samples close together are inferred to resemble one another in species (=variables) composition.

Samples with similar species composition have similar environments

Distance from origin reflects magnitude of change

•Origin: species averages. Points near the origin are average or are poorly represented

•Species increase in the direction of the arrow, and decrease in the opposite direction

Mid-Atlantic data set

- 64 Sites: DE (11); MD (23); NJ (15); NY (6); VA (10)
- 8 Variables:

1. Vegetation Multi-Metric Index (VMMI)
2. Diatom Shannon-Wiener Diversity Index (SW Diversity)
3. Diatom Dominant Taxa (Dominant Diatom)
4. Diatom Centric/Pennate (Centrales / Pennales)
5. Nonnative Plant Stressor Indicator (NPSI)
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Results: Mid-Atlantic PCA

PCA Axis 1: VMMI and NPSI have the highest contribution to Axis 1

VMMI and NPSI are strongly negatively correlated

Left quadrants comprise sites with higher VMMI, increasing to the left, i.e., in direction of VMMI arrow

Right quadrants comprise sites with higher NPSI increasing to the right, in direction of NPSI arrow

PCA Axis 2: HMI has the strongest contribution followed by B1H, and HDIS. HMI and SW diatom diversity are positively correlated. Dominant diatom is negatively correlated to SW and HMI.

Upper quadrants have higher HMI, B1H and diatom diversity, all increasing upwards, i.e., in direction of their arrows

Sites in lower quadrants have lower HMI, B1H and diatom diversity, and higher Dominant Diatom proportion

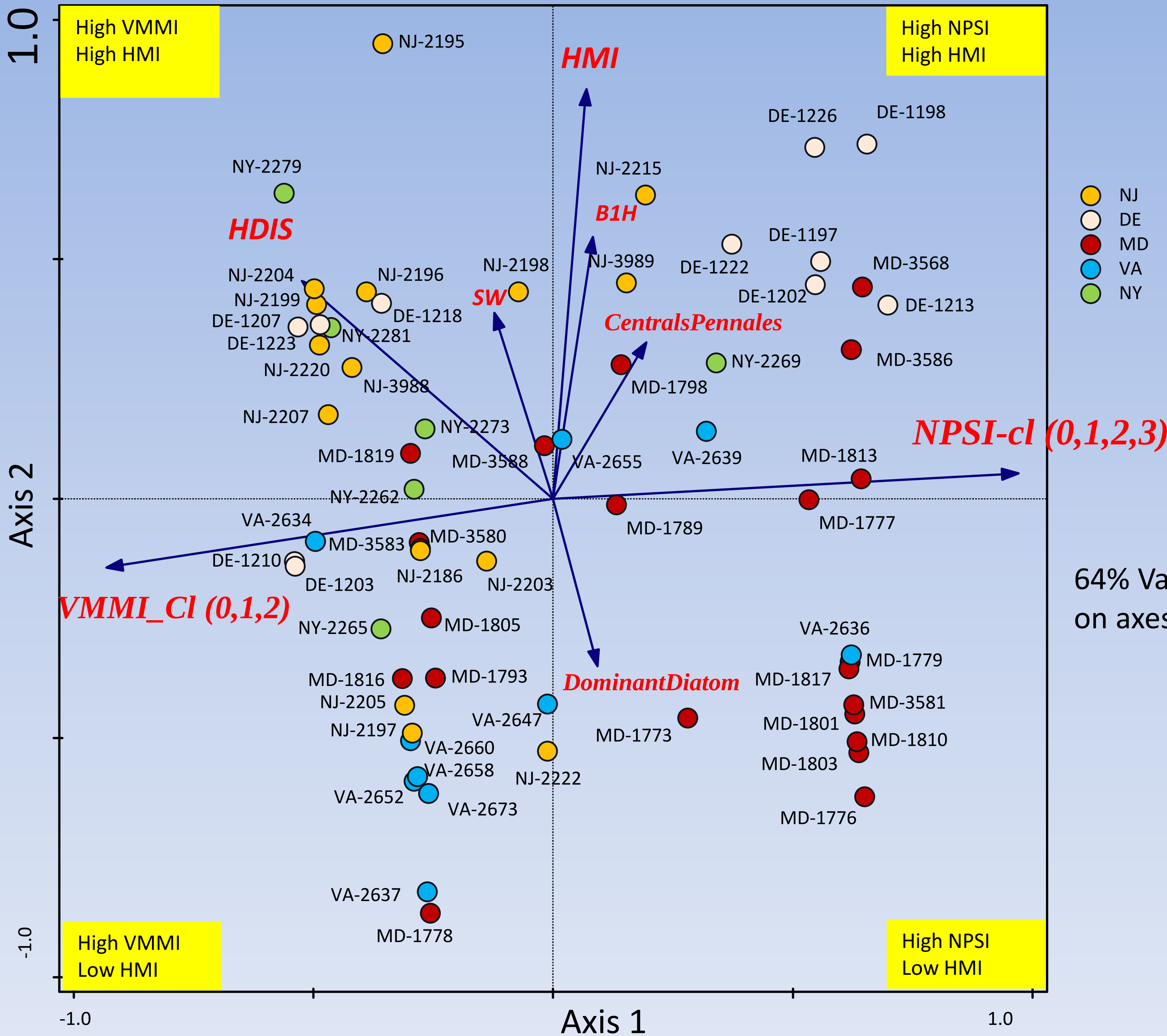
Centrales/Pennales Ratio , Dominant diatom, SW Diversity do not contribute much to first 2 axes; they contribute more to a 3rd / 4th axis, and explain a smaller proportion of variance in this data set.

Results: Mid-Atlantic PCA

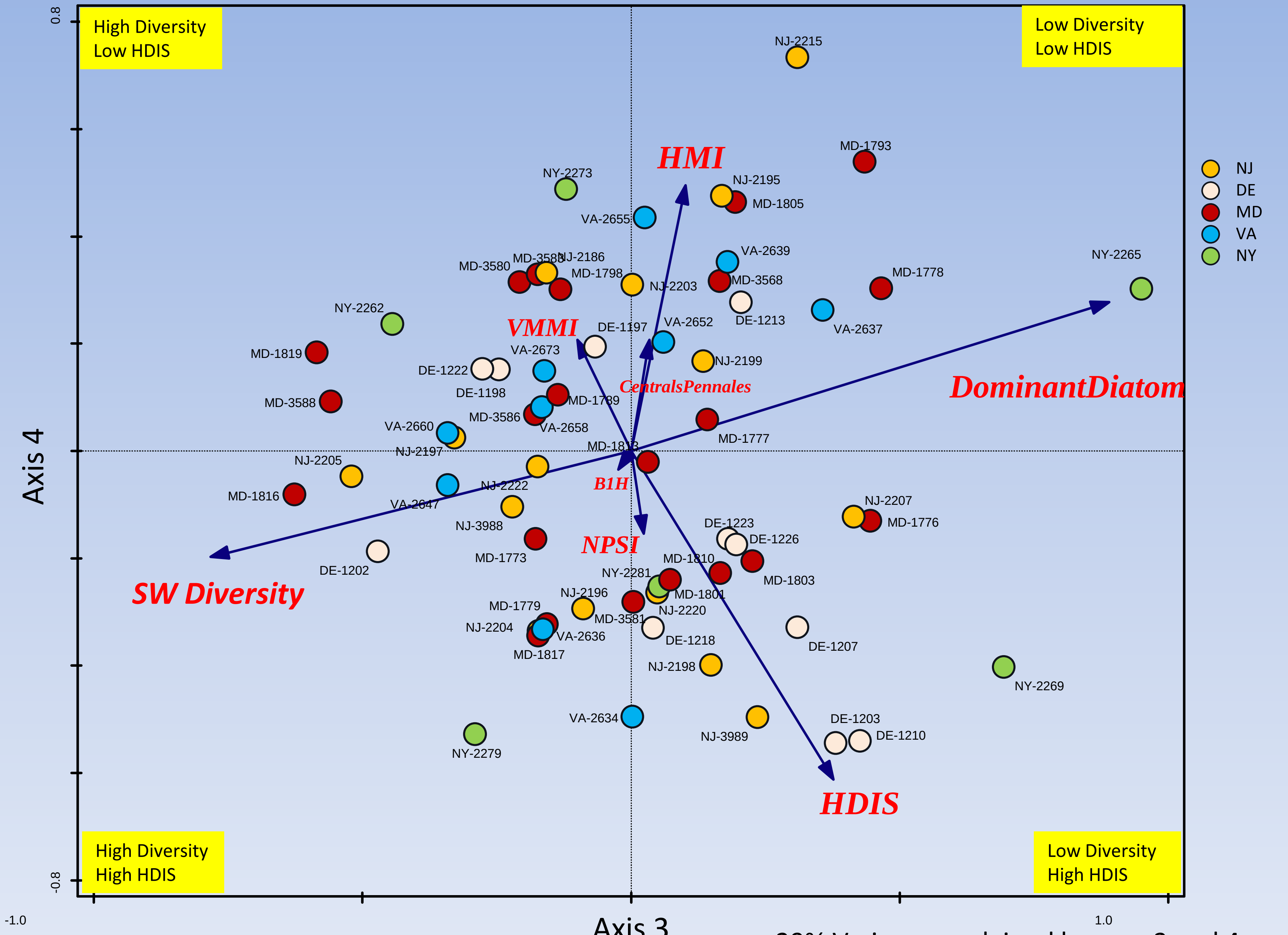
Summary Table:

Statistic	Axis 1	Axis 2	Axis 3	Axis 4
Eigenvalues	0.44	0.20	0.15	0.14
Explained variation (cumulative)	44.42	64.03	79.60	93.49

MD-1788 – excluded no data in HMI



64% Variance explained on axes 1 and 2



29% Variance explained by axes 3 and 4

PCA results summary

- Most important variables in Mid-Atlantic data set are:
  - VMMI and NPSI, highly contributing to Axis 1 (44% variance);
  - HMI (main contributor to Axis 2 (20% variance)
  - Diatom Diversity and Hydrology contribute to axes 3 & 4 (~30% variance)
  - NJ wetlands are strongly impacted by stressors such as heavy metals & hydrology
  - In contrast, MD receives little impact from these stressors despite high NPSI
  - Best conditions: VA, and some MD, NJ sites

Thank you!